- Level of compaction achieved during construction of disposal structures and moisture content in the waste during the construction process governs the rate of leaching process and discharge of contaminants.
- Amendments such as agricultural lime, cement kiln dust and coal combustion byproducts modifies both the physical and geochemical properties of the fill and as a result affect both the stability of the structure and the chemistry of any leachate from the facility.
- Characteristics and thickness of final soil cover significantly affects the leaching and contaminant discharge process. Acidic- and sulfate-bearing discharges may be reduced where well-designed, engineered covers are emplaced. These include a compacted layer for limitation of infiltration into the acid-and sulfate-forming material overlain by a higher hydraulic conductivity layer for drainage (the capillary-break layer) and then a non-compacted rooting medium at least 2-foot thick.
- Any long-term erosion and subsequent exposure of waste in their respective impoundments may accelerate the oxidation process and discharge of contaminants.
- Contemporaneous reclamation has significant impact on the water quality. Wherever feasible the timely covering and revegetation of acid- and sulfate-forming materials will aid in reducing sulfate discharge.

4.12 Inter-relationships between Factors

There are several factors within the above-mentioned groups that may have interrelation with other factors and water quality. For example:

- Elevated chloride levels can affect sulfate level due to the *ion pairing* effect.
- Presence of $CaCO_3$ can affect sulfate level, but only under conditions of high pH, calcium and sulfate concentrations.
- Presence of $CaCO_3$ generally does not affect the chloride level.
- Compaction of waste affects its permeability and geotechnical properties.
- Subsidence or ground movement fractures may expose active mine workings to pre-existing mine workings and pollution sources.

4.13 Good Management Practices

During the mine permit applications review process, the project team identified several practices as good practices from sulfate and chloride discharges control point of view.

- Covering of weathered refuse with fresh refuse in a timely fashion to minimize acidifying the weathered and oxidizing waste. However, this practice was not extensively observed at the mines visited.
- Mixing alkaline waste materials such as cement kiln dust (CKD) or alkaline coal combustion byproducts (Type C fly ash or fluidized bed combustion ash) in bulk with CCPW prior to disposal to increase base neutralization potential and making it relatively impermeable to air and water. Obviously, this practice can only be

adopted if economic potential for management of such materials exists at the mine.

- Improved slope design with potential to eliminate some terraces and drainage channels on the inside and outside slopes of disposal structures that collect leachate and let runoff to infiltrate the structure. Such practices allow increased acidification and sulfate discharge from the refuse and also negatively impact structural stability. Improved slope design is possible today with innovative design software such as *Natural Regrade* by Carlson Software of Mayfield, Kentucky.
- Locating dilution lakes and sediment ponds below reclaimed areas to catch fresh water run-off.
- Moving slurry discharge points. However, the moving was not frequent enough and the discharge pipe was too far from the pond water surface at the mines visited.
- Application of slurry distribution manifold at a few mines.
- Application of co-disposal of CCPW and dewatered FCPW.

4.14 Inappropriate Management Practices

During mine visits, some management practices were observed that would have potential to increase the sulfate and chloride levels in the surface discharge water.

- Refuse was apparently exposed for long periods without covering it with fresh unoxidized waste or compaction.
- Constructing CCPW disposal structures in thicker lifts (one foot or greater) that would result in lower compaction levels and larger permeability to air and water.
- Non-compacted haul roads and safety berms may be an additional source for sulfate. Although the roadway surfaces are in some cases well compacted and resistant to weathering, some facilities are characterized by loose, deeply rutted haul roads. Typically, the safety berms and roadway out-slopes were non-compacted and were subject to weathering.
- Placement of coal refuse high in the backfill for extended periods of time at surface mine sites.
- Allowing deltas to develop in slurry ponds without ponded water that would allow oxidation and weathering of the FCPW sediments.
- Application of fixed slurry pipe discharge points.
- Minimal compaction of CCPW in some refuse disposal areas especially on and near out slopes and equipment safety berms.
- No apparent systematic discharge (blow-down) of high sulfate and chloride water within the coal washing circuit. The use of water with a relatively low sulfate and chloride in the coal preparation plant is needed to minimize excessive formation of readily-soluble desiccation salts (i.e. calcium chloride, calcium sulfate, and magnesium sulfate) on fresh coal waste and clean coal surfaces.